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CONCEPT MAPPING, EVOLUTIONARY BIOLOGY AND READING: A TRANSDISCIPLINARY APPROACH

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Abstract. . In order for effective learning to take place, a favorable environment is crucial. A great deal of such environment can be built through the use of specific tools and approaches. In this study we have concentrated our efforts on the learning-teaching of concept maps and reading techniques transdisciplinarily to improve graduate students' understanding on Evolution Biology. For such, two Biology teachers and one Portuguese language teacher developed a 15-hour workshop at a research center in Belo Horizonte, Brazil. The three teachers worked simultaneously during the entire workshop. During this period the students worked on concept mapping construction, from loose concepts on slips of paper to complex concept mapping on complex texts on Evolutionary Biology. This article shows the students' progressive understanding of relevant concepts on Evolutionary Biology through concept mapping and reading strategies. The results that arouse from the analyses of the maps and the field notes show that there was a significant improvement on concept mapping, reading and consequently on the understanding of important concepts on Evolution Biology issues discussed during the week. The results also show that the constant interaction during the workshop was of great importance to the students' overall development. At the same time, results suggest that there should be a more systematic and continuous work on transdisciplinarity and concept mapping in educational institutions so that it would be embedded on their syllabus.
Keywords: Concept Map, Evolutionary Biology, reading, transdisciplinarity, higher education

1 Introduction

The application of Concept Maps has been widely used in the educational field. Within this context, there are studies that correlate many areas of knowledge. In the Science Teaching field, there are studies correlating concept mapping with Science Teaching or Evolutionary Biology (Beeson, V. & Culp, T.; Germann, P., Young-soo, K., Patton, M.D., 2001) and with Higher Education (Hay, D., Kinchin, I., Lygo-Baker, S.). Other studies correlate concept mapping with reading (Freire, ABMS, 2005; Freire, ABMS; Freire, ASF, Gregório, R., 2006) and concept mapping and pedagogical practice (Freire, ABMS & Freire, ASF, 2010). It is of no doubt that all these studies are of great relevance in the field of Concept Map as a tool or a strategy for meaningful learning. Such studies show that more attention is being paid to the efficacy of Concept Maps as well as to the crucial need to think and learn meaningfully. However, there seem to be no study comprehending the three areas altogether on Higher Education: concept mapping, Evolutionary Biology and reading.

This study focuses on the teaching-learning of Evolutionary Biology for Higher Education students using concept mapping and reading strategies. The aim of our investigation was to enhance meaningful learning in Evolutionary Biology through Concept Maps and reading strategies.

2 Methodology

An initiative is now under way to develop methods to aid the user during concept map construction. These aids are designed in response to observations of snags which may arise during concept mapping. During concept mapping, users often stop and wonder what other concepts they should add to the concept map they are working on, frequently spending time looking for the right word to use in a concept or linking phrase; they search for other concept maps that may be relevant to the one they are constructing, and they search through the Web looking for additional material that could help them enhance their maps. The following sections describe three methods developed to address these issues.

2.1 Theoretical Framework

The theoretical framework for this study was transdisciplinarity and socio-interacionism, together with reading comprehension strategies, such as pre-reading, reading, keyword recognition and contextual inference (Grellet, 1981).

The perspective of language, specifically of reading as a social practice is present in the studies of Bakhtin (1986), Koch (2003; 2006) and Matencio (2002): the text does not have meaning in itself but in the reader's interaction with the text and with the environment "the student must be an active participant of this interaction, grounding themselves on text cues as well as in their vision of the world." (Matencio, 2002, p.41). Reading is a social practice and the meaning of is, therefore, a social construction. (Koch, I.V., 2003, p.30).

The concept of sharing meaning is also present in concept mapping: "When concept mapping is done in groups of two or three students, it can serve as a useful social function and also lead to lively classroom discussion." (Novak, 1994, p.20). Such view corroborates with Vygotsky's social-interacionist perspective of learning: knowledge implies on shared information among peers and that learning happens more effectively with the help of others. Based on this perspective, a great deal of students' concept maps were madi in groups, thus enhancing interaction.

The workshop was also designed to be transdisciplinary: the three teachers worked simultaneously inside the classroom in order to integrate Biology and reading comprehension, thus promoting decompartmentalization of knowledge (Freire, A.B.M.S., 2005). During the whole workshop these two areas(Biology and reading coexisted and interacted dynamically with a common goal (Moita Lopes; Celani, M.A.A., 1998). Such procedure corroborates also with Morin's (2007) definition of transdisciplinarity. According to the author, "transdisciplinarity surpasses the particularity, conjugates knowledge and makes it such that different means work for the same purpose." (Audy J. L. N., Morosini M. C. (Orgs.), 2007, p.30).

2.2 The Workshop

The workshop lasted 15 hours, distributed within five days in a roll. In general, the time was distributed as follows: reading, concept mapping, and discussion of the texts. There was a discussion about the texts after each reading. As said in 2.1, most of the times students worked in groups. The groups were constantly rearranged to enhance interaction.

The workshop was divided into four phases, with a progressive increase in difficulty. On phase one, we used sets of loose concepts, written on slips of paper. Each set was about a specific topic, such as "school subjects" and "Olympic Games". In groups, students should make a concept map using the loose concepts on a card paper and present the map to the class. There was a debriefing (discussion) after each presentation about the arrangement of the maps, After the discussion, students were presented to theory about concept maps and about the biological foundations of learning.

On the following phases students worked with texts, arranged according to two aspects: readability and content. Each aspect obeyed different evaluation criteria. To evaluate readability we used the Flesch score. The content analysis was made by the Biology teachers based on the content complexity of the texts given.

On phase two each group received simple texts – Flesch average level = 60 (easy) and content complexity = 0.5 (very easy) – and the corresponding average complexity) partially completed map. They should read the texts and fill in the maps. On phase three the texts on Evolutionary Biology, thus were more complex and more specific, with Flesch average level = 43 (difficult) and average complexity = 1.13. On phase four the texts were also about Evolutionary Biology and had a higher level of complexity (Flesch score = 31 (difficult) and average complexity = 1.42. On this phase students built free maps exclusively: one map in group and then two individual maps.

Table 1 shows the Flesch score. Table 2 shows the content complexity averages of the text used.

Table 1: Flesh score. Source: Silva, C.A.T., 2009

Flesch score	Legibility	Instruction level
100 - 75	Very easy	Elementary
74 - 50	Easy	Junior High
49 - 25	Dificult	High School and graduation
24 - 0	Very difficult	Academic texts

Table 2: Biology teachers' texts score pattern based on content complexity

EASY	AVERAGE COMPLEXITY	DIFFICULT
0.0 A 0.59	0.6 A 1,59	1.6 A 2.0

Figure 1 shows a concept map of the workshop methodology

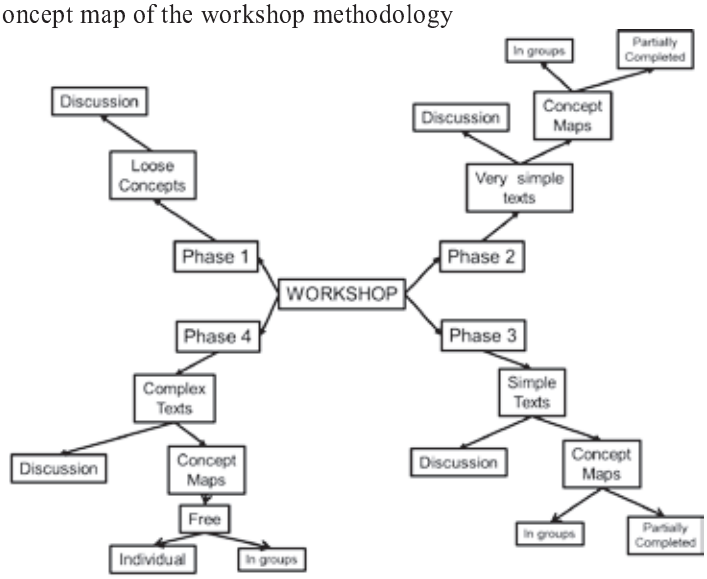

Figure 1: workshop methodology concept map

2.3 Context, Field Participants and Material

The study was designed as a workshop, which took place in the last week of January, 2014 at René Rachou Research Center (CPQRR), in Belo Horizonte, the state of Minas Gerais, Brazil. It was designed mainly for Biology students of this institution. The participation was free of charge and limited to a number of 30 participants. The two main criteria for enrollment were to be a Biology student at the CPQRR and to be working on a line of research. The teachers were from different institutions: CPQRR, UERJ (University of the State of Rio de Janeiro) and CBPF (Brazilian Center of Physics Research) Physics and Humanities Group.

The data used in this study were: photographs, field notes and the students' concept maps.

Field notes have been taken during all the discussion after concept maps construction as said in workshop description. Such notes had been used together with the concept map to registrate participants impression about the learning process itself, the students' progess and indicate when there are some conceptual changes.

2.4 Concept Maps Analyses

Teachers had read the texts and had made the correspondent concept maps. Such maps have being used as reference to students' maps analyses. To evaluate the maps there were taken some criteria were taken into consideration such as capacity of concept hierarchization, identify important concepts and map spatial organization.

Concept maps analyses began establishing the relation between the rising difficulty of the texts and students performance in concept mapping. In order to establish this relationship we used Pearson correlation and Flesch index describe as follows.

2.4.1 Pearson Correlation

The Pearson linear correlation is used to indicate the intensity of a linear correlation between two sets of data. In other words, It is a statistical approach that allows us to observe if the "increase or decrease of a variable X have the same impact in the variable Y" (Figueiredo-Filho e Silva-Júnior, 2009). The Pearson correlation index "r" is calculated as follows:

$$r = \frac{1}{n-1}\sum\left(\frac{xi-\bar{X}}{sx}\right)\left(\frac{yi-\bar{Y}}{sy}\right)$$

Depending on the result of "r", the correlation vary from perfect positive (r= 1) to perfect negative (r= -1). If r=0, it implies on the absence of linear interdependence. But there can be another non-linear dependence, and r=0 must be investigated by other means.

Pearson correlation has been used to establish the relationship between the difficulty in reading comprehension and students' performances. By using this tool we aimed to investigate if students' mistakes would raise proportionally to the complexity of texts.

2.4.2 Flesch Score

Table 3 shows the Flesch score average and the content complexity of the texts given. Flesch method is used to classify the legibility of a text in a scale that goes from zero (difficult) to 100 (very easy).

Table 3: written material and corresponding Flesch score and the content complexity averages

	Material	Flesch score average	Content complexity average
PHASE 1	Loose concepts	-----	-----
PHASE 2	Very simple texts	60	0.5
PHASE 3	Simple texts	43	1.13
PHASE 4	Complex texts	31	1.42

3 Results and Discussion

First of all, we can highlight that the fact that the workshop was transdisciplinary based was essential to the interaction of the group, as many of the students didn't know each other. It was also a great opportunity to discuss about their own learning process. In other words, they could participate actively in the proposed activities. The transdisciplinarity was also an overall gain in terms of discussion about the Evolutionary Biology concepts themselves as well as the concept mapping construction. We could discuss the presented issues more dynamically. Working transdisciplinarily also provided more dynamic classes and, consequently, more interaction.

Secondly, groupwork stimulated their participation in the activities. The students gradually felt more self-confident and independent. From the arrangement of the chairs to the constant rearrangement of the groups, every activity seemed to have helped them socializing with their college mates, creating a pleasant atmosphere.

Thirdly, working with reading strategies and with a socio-interactionist view of the process of reading empowered the students in the sense that they have power over what they read, and that texts are not a bucket of meaning. If meaning is constructed through interaction, therefore we can discuss, agree, and disagree with what we read. This empowerment leads naturally to critical reading, a fundamental characteristic in the academic world.

Concept Maps also provided an effective way of understanding the text, no matter its complexity. It can be perceived on the results of the last concept mapping: even the corresponding text having a Flesch score of 33 (very difficult) and a complexity score of 1.75 (difficult), students' concept maps were more complete and better organized than any of the previous individual maps.

The results are presented as follows: a correlation table, a figure showing students' improvement on concept mapping, and sketches of some students' concept maps.

Table 4 shows the Pearson correlation between the level of difficulty of the texts used (Flesch score) and the average of students' right concepts of their maps during the workshop.

Table 4: Pearson correlation between the right concepts present on students' maps and the Flesch score: R=0,7963.

Flesch Score	Right concept
59	0,78
60	0,83
59	0,63
62	0,54
42	0,53
41	0,63
46	0,45
43	0,27
33	0,39
28	0,11
33	0,30

The R=0,7963 indicates a strong relation between the decrease in the Flesch score (therefore, an increase in the difficulty of the texts) and the attainment score of the concept maps: the difficulty of the maps construction is proportional do the difficulty of the texts.

The first free map was made in group. In this activity students had to deal with the challenge of build the map itself, as it was the first time they were building a map with no help concerning structure or hints of concepts. As to the second and the third last maps, students had to deal with two difficulties: to build them alone and with no structural of concept hints. Naturally, the performance decreased on the second free map, which corroborates to Vygotsky's theory of the most developed pair. But Vygotsky also point out that, if a student can reach a higher level of comprehension with their peers, they are prepared to reach it alone. And that is what is shown on the discussion of the last text, reflected on their last map: the right concepts average triplicates in comparison to the previous map. The maps also show a clearer and more accurate hierarchy. Such improvement can be translated as a gain in autonomy and also a better texts comprehension, which is, then, seen in their improvement in concept mapping during the workshop.

The field notes from Jan.30 and Jan.31 show that students are more participative during the discussions and signalize the attainment of new concepts as well.

Next, figure 2 shows how students improved their concept mapping by the end of the workshop.

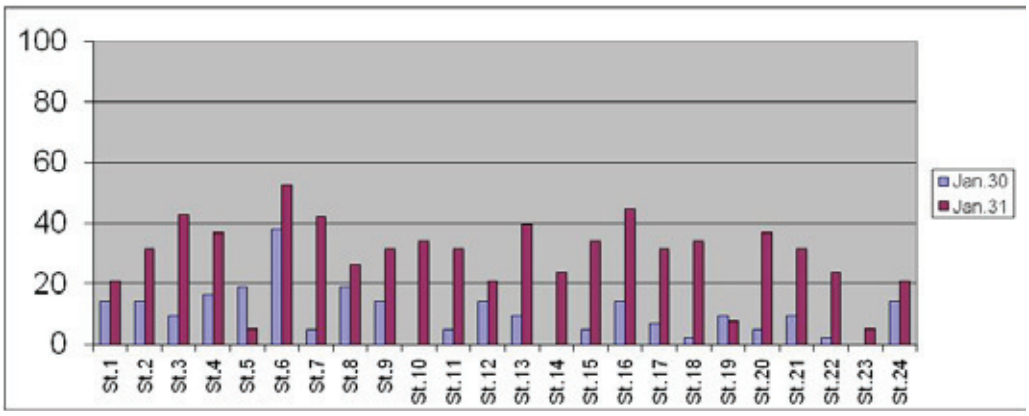

Figure 2: students' maps concept attainment score on phase four (%)

Figure 2 shows the progress of the students' individual maps. The maps made on January 30th show that students could hardly get the main ideas of the text. Based on the score and considering that concept maps reflect their comprehension of the texts, students could not understand 20% of the first text. On the other hand, their students' maps on January 31st show a considerable improvement. Among the 24 students assessed, 19 improved significantly.

Students' improvement on reading was quantitative as well as qualitative. This can be noticed on their individual free maps. Apart from the number of concepts in the maps, the hierarchical organization also improved. Figures 2, 3 and 4 show this improvement.

Apart from the analysis of phase 4, an overall improvement can be noticed: the analysis of the Pearson correlation between the increase of text difficulty and the students' difficulty in building the concept maps. As said in the methodology, the strong Pearson correlation (R=0,7963) shows the proportional relation between the difficulty in reading the text with the difficulty in building the maps. But, despite this difficulty, students' comments during the discussions made themselves clear in relation to their gradual progress.

The comparison of the first and the second individual free maps reveal that students managed to improve substantially in concept map construction. Such improvement can be seen in their improvement in concept attainment and hierarquization.

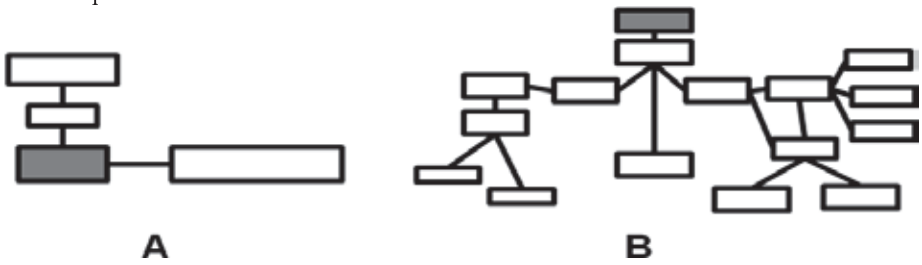

Figure 3: comparison between a student 3's first (A) and the second individual free map (B).

A Figure 3 shows an example of the difference between the first and the second free maps. Fig 3A shows and excessively reduced map. On the other hand, Fig. 3B shows a considerable improvement in organization and concept attainment.

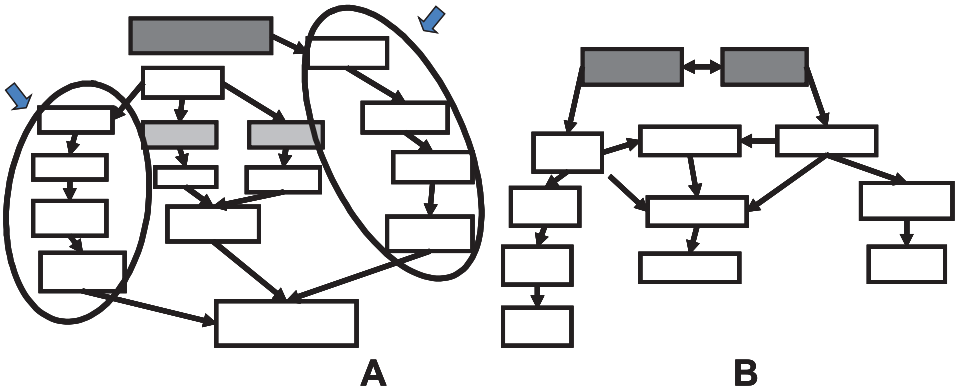

Figure 4: comparison between a student 11's first (A) and the second individual free map (B). Dark grey: main concept; light grey: repeated concepts.

Figure 4 shows another example of the difference between the first and the second free individual map. In Fig. 4A the hierarchical organization is not clear. From the main concept on, we note that there is a linear subordination up to the end of the map. There is no link between the main concept and the immediately subordinated one. Also, there is a concept that was repeated, showing difficulty in understanding the text and therefore difficulty in the organizing information. Fig. 4B shows better organized concepts as there are links among them and, at the same time, it shows a clearer hierarchy. We can also note that there is no repeated concept as in Fig.4B.

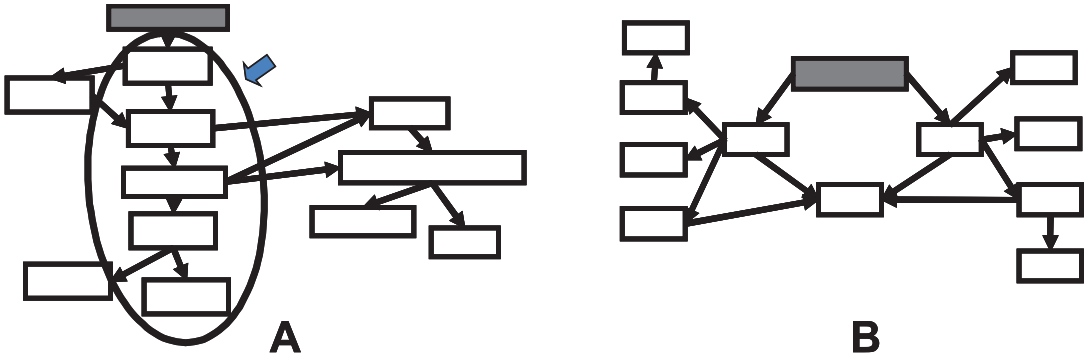

Figure 5: Comparison between the student13's first (A) and the second (B) individual free concept maps

Figure 5 shows another example of the difference between the first and the second free individual map. Fig. 5A shows linear organization in the center of the map. The connections with the left part of the map don't show a clear relation among the concepts. On the other hand, fig 5B shows clearer relations among the superordinate and the subordinate concepts.

Students gradually gained more autonomy and self-confidence: they continuously perceived that meaning is constructed and not something to be searched or reached. This augmented their power of criticism on the texts.

Also, they learned to expose their points of view, as they perceived that they were not detectives searching for some sense, but agents of the construction of meaning.

The overall results indicate that the students in one week only improved their organization of thought, their text comprehension and widened their knowledge and understanding in Evolutionary Biology.

In relation to the discussions along the workshop, we understand that this space for dialog (Bakhtin, 2003, 1981) was crucial to the good performance of the students and the teachers. There was much more than just give them texts and ask them to make maps. The discussions moments were vital for deconstructing rooted beliefs was that the meaning of the text is in the text itself, and that the student's only role was to extract the meaning from it (a behaviorist view) – a common misuderstanding (still present nowadays, even in scientific articles) - in opposition to the socio-interactionist view of reading (search for meaning x construction of meaning).

Considering its relation to Ausubel's theory of anchoring, its possible to affirm that meaning is also a construction the students make in order to learn meaningfully. This point is crucial for the meanings are constructed and that this construction is the only way for learning to happen meaningfully and not be transformed into many memorized concepts or ideas. We believe that learning can only happen when there is critical thinking and a politicized attitude towards life.

4 Future Studies

As students' improvement in reading, reflected on their maps, improved considerably, future studies could systematize and make permanent the work with concept maps involving more consistently the three institutions (UERJ, CBPF, and CPqRR). In order to achieve it will be necessary a long term project with workshop twice a year in two different institutions. An institutionalized research group must be constituted so that students can be accepted work in this research enterprise.

5 Summary

The aim of the workshop was to enhance reading the use of Concept Maps in Evolutionary Biology for Higher Education students. In order to make it happen, we have elaborated a workshop for Biology students at a research center in Belo Horizonte, Brazil. The workshop lasted 15 hours equally distributed in five days. During the workshop the students worked on reading strategies, concept mapping and discussions on Biology issues. We have analyzed students' maps and compared their performance along the workshop. As the results show, there was an outstanding improvement on concept mapping, which pictures their improvement in reading and text comprehension.

6 Acknowledgements

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